Plant pest risk information system (PPRIS) for USDA-APHIS: design of a functional prototype

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The Plant Pest Risk Information System (PPRIS) is a computerized decision-support system for plant pest risk assessment in the USA, being developed for use by personnel of the US Department of Agriculture's (USDA) Plant Protection and Quarantine, Animal and Plant Health Inspection Service (APHASIA). PRIS is being designed to retrieve information for such diverse sources as: EPPO PQ database, USDA-Agriculture Research Service's (ARS) Fungi on plants and Plant Products database, bibliographic databases on compact disc media, on-line INTERNET databases and risk assessment documents. PPRIS will offer access to a wide variety of risk assessment processes. A PPRIS evaluation prototype was created in Visual Basic ver. 3.0 operating in a Windows 3.1 environment. EPPO-PQ and ARS-Fungi databases were imported and stored in ORACLE ver. 6.0. Query functionality of the prototype was tested by retrieving information from the two internal ORACLE databases. The PPRIS evaluation prototype provides interfaces to the CABPEST bibliographic compact disc and to communication software for on-line database searches. Three risk assessment processes were incorporated into the evaluation prototype; the decision sheet generic risk assessment and enhanced hazard identification. The evaluation prototype also includes access to Wordperfect for windows though the Windows Program Manager for storage and retrieval of risk assessment documents.

Introduction

Pest risk assessment is becoming an increasingly more sophisticated tool for regulatory decisions concerning agricultural imports. The US Department of Agriculture's Economic Research Service (USDA-ERS) values agricultural imports in the USA for 1993 at 24.5 billion USD (USDA, 1994). The volume of agricultural imports has increased over the years. For example, over a 5-year period (1989-1993), USDA-ERS reported a 20% increase in volume of imported fresh bananas, 20% increase in volume of imported fresh cucumbers, and a 35% increase in volume with respect to imported tea (USDA, 1994). The reason for this rise in volume of agricultural imports seems to be the increased diversity of agricultural products from a greater number of worldwide geographic locations.

Concern has been raised about the increased pest risk associated with this rise in volume of agricultural imports. Large numbers of complex and detailed pest risk assessments are being required to support regulatory decisions regarding the increased world trade. This complex situation may best be served by an automated system for information retrieval from diverse sources that also provides a way to track the progress of assessments and includes a variety of risk assessment methods. The purpose of this paper is to report on progress towards a computerized decision-support system that would provide information for pest risk assessment decisions and to describe a functioning prototype of that system. The computerized system is herein known as the Plant Pest Risk Information System (PPRIS).

Design for the plant pest risk information system

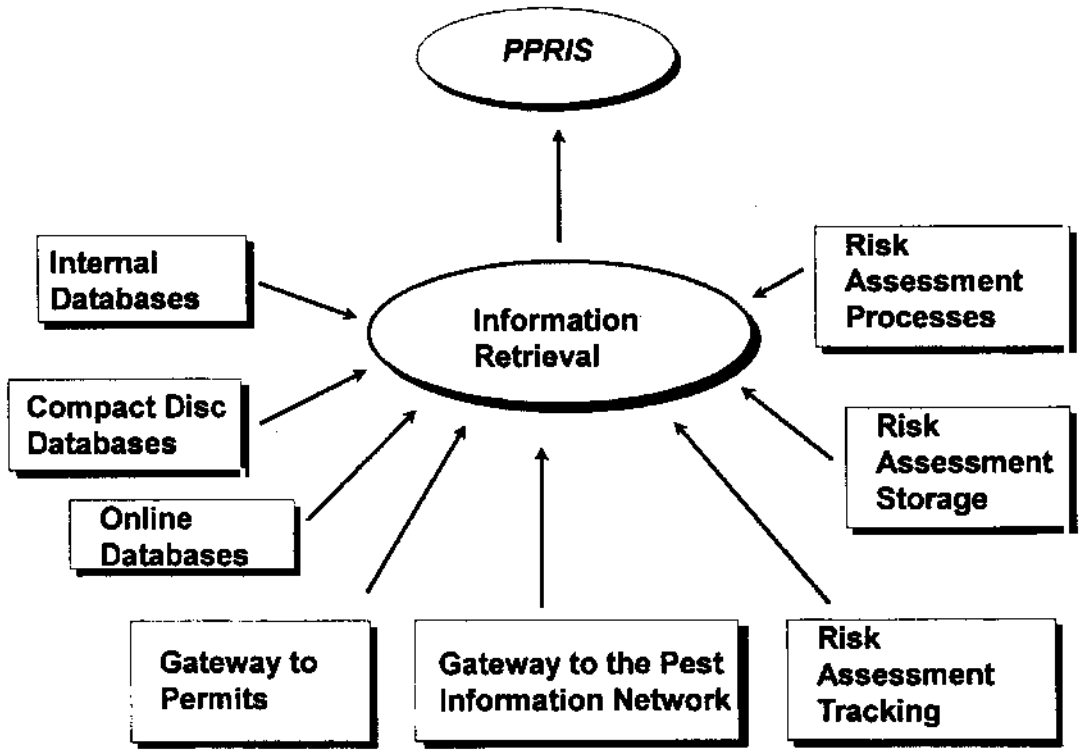


Fig. 1. Design of PPRIS.
Structure de PPRIS.

PPRIS is designed to be used in a local area computerized network composed of a relational database, bibliographic databases on networked CD-ROM drives, document imaging and storage and access to outside on-line databases by modem (Fig.1). Data inputs to the system will include the PQ database of EPPO and the Fungi on plants and Plant Products in the USDA database of USDA's Agricultural Research Service (ARS), as well as access to compact disc bibliographic databases, an imaged document database and data entry from external sources. The PQ database (EPPO) is a relational database created in dBase IV composed of plant pest names, host plant names, countries, relationships between geographical entities, host-pest combinations and country-pest combinations. It includes datasheets on quarantine organisms and information from the Food and Agriculture Organization and other regional plant protection organizations (Smith & Smith, 1991). Fungi on Plants and Plant Products in the USA is a database which contains taxonomic and geographic information about fungi and plant hosts (Farr et al., 1989). Users of PPRIS will also be able to access bibliographic references from compact discs provided by the CAB International (CABI) (1984-present), Agricola (USDA, 1984-present) and USDA's National Agricultural Statistics Service. The imaged document database will contain plant pest risk assessments and related documents stored in a relational database for retrieval by PPRIS. The design for PPRIS also allows for the incorporation of a wide variety of processes necessary for pest risk assessment.

The system is currently designed to produce risk assessments, output reports and display imaged documents, bibliographic databases and on-line databases. PPRIS will be able to generate reports on host(s) in a locality, pest(s) of a host, geographic distribution of a pest, pests on hosts in a locality, organism name(s), risk assessment for a host, risk assessments for a pest, risk assessments for a locality and risk assessment status. Users will retrieve imaged documents with keyword search queries from the relational database. PPRIS will access a CD-ROM drive through the local area network, and a query search by keywords will elicit the necessary subject matter references.

Users will be able to access outside on-line Internet databases through high-speed modems. Some examples of outside databases are Fungi on Plants and Plant Products in the USA, Germplasm Resources Information (GRIN), Index to Saccardo's 'Sylloge Fumgorum', Scientific Names of Vascular Plants in the USA, Literature Guide for Identification of Plant Pathogenic Fungi and Norrbom's Anastrepha, Fungi on Plants and Plant Products in the USA is a database available on-line from the National Fungus Collection at USDA-ARS, Beltsville, Maryland. GRIN is another on-line database that contains vascular plants, both cultivated and wild. GRIN includes over 445,000 types of plants with information on morphology and pest resistance. Information in GRIN also includes taxonomy for over 50,000 current scientific names and synonyms. The GRIN system is also available on-line at USDA-ARS, Beltsville, Maryland.

Systems analysis

Scope

The first step of the systems analysis was to identify the statement of purpose for the system and the events that were expected to occur in the system. Potential users were interviewed and a statement of purpose was generated (Cohen, S.D.& Damours, J.D., pers comm.[1]). Users agreed that the purpose of PPRIS would be to automate a comprehensive decision-support systems to identify, assess and develop recommendations for the management of pest risks association with exotic and emerging organisms affecting plant resources.

Ongoing interviews with potential users were conducted to help define the immediate and future needs for the system. After further input from potential users was collected a context diagram defining the scope of the system was created. A risk assessment workgroup was established to give immediate feedback in developing the data and functional models for PPRIS, surveys were given to a wide group of risk assessors to identify additional data sources and risk assessment needs (Cohen, S.D. & Damours, J.D., pers. Comm.[2]).

In order clearly to define the data and functional requirements of PPRIS, the systems analysis team used structured-analysis techniques. These techniques provide for logical modeling of data and functions and encourage analysts to think precisely about the functions of the system, the data it will incorporate and the boundaries of the system. PPRIS was designed using the structured-analysis approach for data and functional modeling

Yourdon, 1989).

[1] APHIS report 'Plant Pest Risk Information System Interview Records' available from author, Cohen, S. D.
[2] APHIS report 'Requirements specification: Plant Pest Risk Information System' available from author, Cohen, S.D.

Functional model

The functional model supported the maintenance of tables, intuitive access by end-users and the generation of reports that supported risk assessment recommendations. Because intuitive access by end-users was considered a high priority, the functional models allowed users easily to create and change a 'search' criterion, e.g. Organism and area combination, and provided the users with easy and flexible access to the tables containing the biological, geographical and interception information. Users could store the results of searches for future reference and could store their 'search' criteria between sessions. Printed reports displayed the data on which risk assessment decisions were based and also provided bibliographic references for the data. The specifications for the evaluation prototype were derived from the functional model (Table 1.)

Table 1. Functional design specifications of PPRIS
Conception opérationnelle de PPRIS

Levels	**Functions**
1	Target Search
1.1	Define Organism Search
1.1.1	Select Organism
1.1.1.1	Select Organism by Common Name, Scientific Name, or Acronym
1.1.1.2	Select Non-Virus like Organism by Class, Order, Family, Subfamily, Gneus, Species, Subspecies
1.1.1.2.2	Select Viruses by Virus Group, Name or Strain
1.1.2	Relate Organism to Another Organism by Role
	Select roles 'lives off' or 'is associated with but does not live off'
1.2	Define Area Search
1.2.1	Select by Area Association
	Select areas related to other areas by trading partners, neighbors, membership in organizations or other relationships
1.2.2	Select by Area Type
	Select area types, e.g. country, continent, province, state, then area name
1.2.3	Select by Hierarchical Relationship
1.2.3.1	Derive by Area Within Other Areas
1.2.3.2	Derive by Area Containing Other Areas
1.3	Select Source of Data
	Select all sources of data or target only EPPO's PQ data or USDA-ARS's Fungi data
2	Query Databases
2.1	Determine Hosts of a Pest
2.2	Determine Hosts in a Locality
2.3	Determine Pests of a Locality
2.4	Determine Pests of a Host
2.5	Determine Geographic Distribution of a Pest
2.6	Determine Pests on Host in a Locality
3	Generate Reports
4	Maintain Data

Data model

The logical data model was designed to provide a high degree of flexibility in accessing biological information related to plant pest risk assessment (Cohen, S.D. Et al., Pers. Comm.[3]). Data attributes (Table 2) and entity relationships (Fig. 2) describe the characteristics and relationships of the data model. The taxonomy of organisms was modeled to allow intuitive movement up and down the taxonomic ladder during queries, e.g. Selecting a family and viewing the genera within the family. The model also supported classes without order, families with subfamilies, hybrids and other relationships. Viruses were modeled for group, name and strain. Both common names and scientific names were supported. A historical record of pertinent names changes was included for users interested in the evolution of organism taxonomy over time. The model addressed the often complex relationships among organisms. It provided for relationships in which an organism might be a pest under some circumstances a host under other circumstances and, perhaps, a natural enemy under others. The model supported vectors, pest stages and host parts. Areas of the world were modeled to allow import of weather data at some time in the future. The model provided for the grouping of countries and other areas into larger geographic areas. It supported relationships among countries such as trading partnerships and membership in organizations like EPPO and the North American Plant Protection Organization. Biological information could be related to individual organisms or to combinations of organisms when needed to describe spread through hosts, vectors, hitchhikers, etc. The model was designed to reflect not only the occurrences of organisms but also interceptions of organisms at points of entry and was intended to interface at some future date with the Pest Interception Network of USDA's Animal and Plant Health Inspection Service.

[3] APHIS report 'Data and functional models for the Plant Pest Risk Information System' available from author, Cohen, S. D.

List of Attributes

Organism
- Organism:
  - Organism ID
  - Pointers to taxonomy
  - Reference
- Nomenclature:
  - Organism ID
  - Name (designated name, scientific name, or common name)
  - Reference
- *Non-virus like organism taxonomy:*
  - Class
  - Order
  - Family
  - Subfamily
  - Genus
  - Species
  - Subspecies
  - Strain
- Virus taxonomy:
  - Virus group
  - Name
  - Strain
- Relationships:
  - Organism #1
  - Pest stage
  - Organism #2
  - Host part
  - Role ('lives off' or is associated with but does not life off')
  - Reference

Distribution
- *Distribution*:
  - Organism ID
  - Locality
  - Reference

Locality
- Locality:
  - Name
  - Type of locality (country, state, region, etc.)
- Relationships:
  - Locality #1
  - Locality #2
  - Relationship (neighbor, is contained in, etc.)

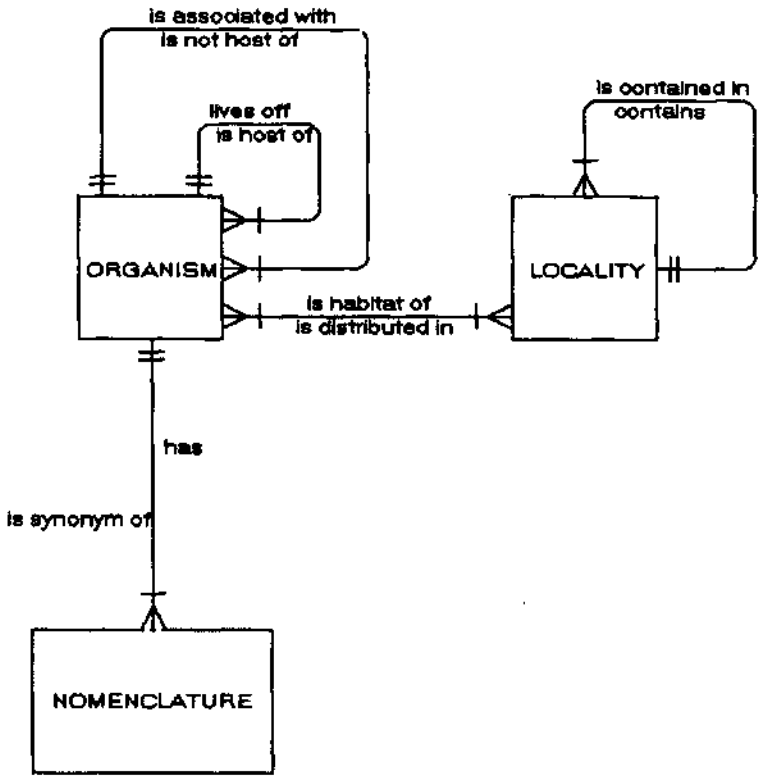


Fig. 2. Entity relationship diagram for PPRIS.
Relations entre les entités de PPRIS.

Table 3. Query performance of the evaluation prototype of PPRIS
Efficacité du fonctionnement du prototype de PPRIS

Databases	Number of Records	Time[4] (s)
EPPO:PQ Database		
• Hosts of *Ceratocystis fagecearum*	2	1
• Locations of *Ceratocystis fagecearum*	5	1
• Pests of India	308	37
USDA-ARS: Fungi Database		
• Hosts of *Ceratocystis fimbriata*	19	4
• Locations of *Ceratocystis fimbriata*	40	3
• Locations of fungus, *Ceratocystis fimbriata*, and host, *Zea mays*	1	21
• Fungi of host, *Populus tremuloides*	229	17
• Location of *Populus tremuloides*	36	29
• Fungi on *Populus tremuloides* in Alaska	26	231

[4] Performance times of PPRIS tested on a 486 ISA-66MHz, 16MB RAM microcomputer configured with 6 MB cache and 4 MB RAM allocation for ORACLE database.

Relational database

The core of PPRIS is the centralized relational database that stores information on plant hosts, pests and geographical distribution of pests. The relational database will be composed of data converted and loaded from the PQ database (EPPO) and the Fungi database (USDA-ARS). The relational database is to be developed in ORACLE software.

Query functions include searching non-viruslike organisms by any taxonomic level, class, order, family, subfamily, genus, species, and subspecies. Viruses are searched by group, name or strain. Organisms can be searched by common name, scientific name, acronyms, synonyms or 'soundex' algorithm for 'sound-alike' names. Additional query functions include identifying countries of a region, identifying neighboring (Adjacent) countries, searching for hosts of a pest, searching for hosts in a locality, searching for pests of a locality, searching for pests of a host and searching for the geographic distribution of one pest.

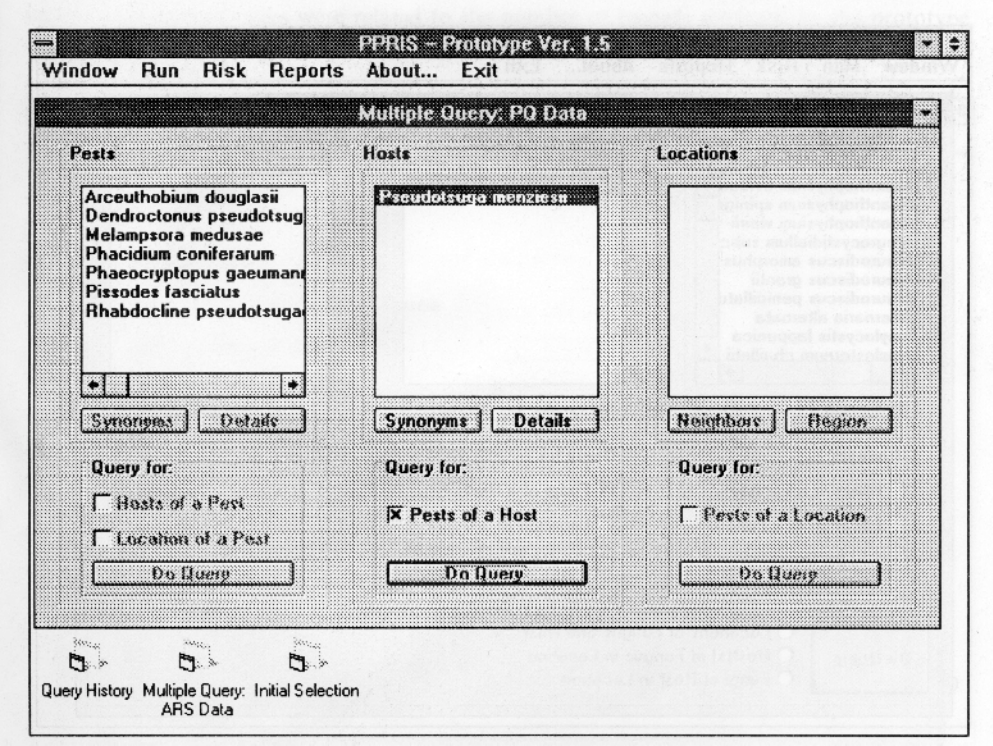


Fig. 3. Example of a query on quarantine pests: the quarantine pests on Pseudotsuga menziesii in the EPPO PQ database accessed through PPRIS.
Exemple d'une interrogation sur les organisms de quarantaine: organisms de quarantaine sur *P. emnziesii* selon la base de données PQ de l'OEPP, avec accés par PPRIS.

Prototype development

The PPRIS evaluation prototype was developed as an application in Visual Basic ver. 3.0 operating in a Windows 3.1 software environment on a stand-alone microcomputer. This software application requires ORACLE database ver. 6 and an MS-DOS operating system ver. 6.2 PPRIS performs well on a 486-66 MHZ microcomputer with 640 K conventional memory and a minimum of 16 MB RAM memory. At this time, the prototype is designed to run on a single microcomputer only, but in the future will operate in a local area network environment.

The prototype is designed to have a Windows menu system for choice selection. Users may choose from **Window, Run, Risk, Reports, About** and **Exit**. The Window submenu includes **Arrange Icons In A Row, Cascade Multiple Screens, Initial Selection Screen, Query History, Multiple PQ Query Screen** and **Multiple ARS Query Screen**. The **Run** submenu provides access to the CABPEST compact disk bibliographic database and the On-line Internet databases. **Risk** submenu includes the risk assessment methods, such as the decision sheet and the generic and enhanced hazard identification processes. **Reports** submenu provides access to printing query reports to the computer screen, to a file or to a printer. The **About** submenu displays information on the current dates of the internal databases, prototype version and staffs involved in development of this automated decision-support system. The **Exit** command on the title menubar allows user to leave the PPRIS prototype.

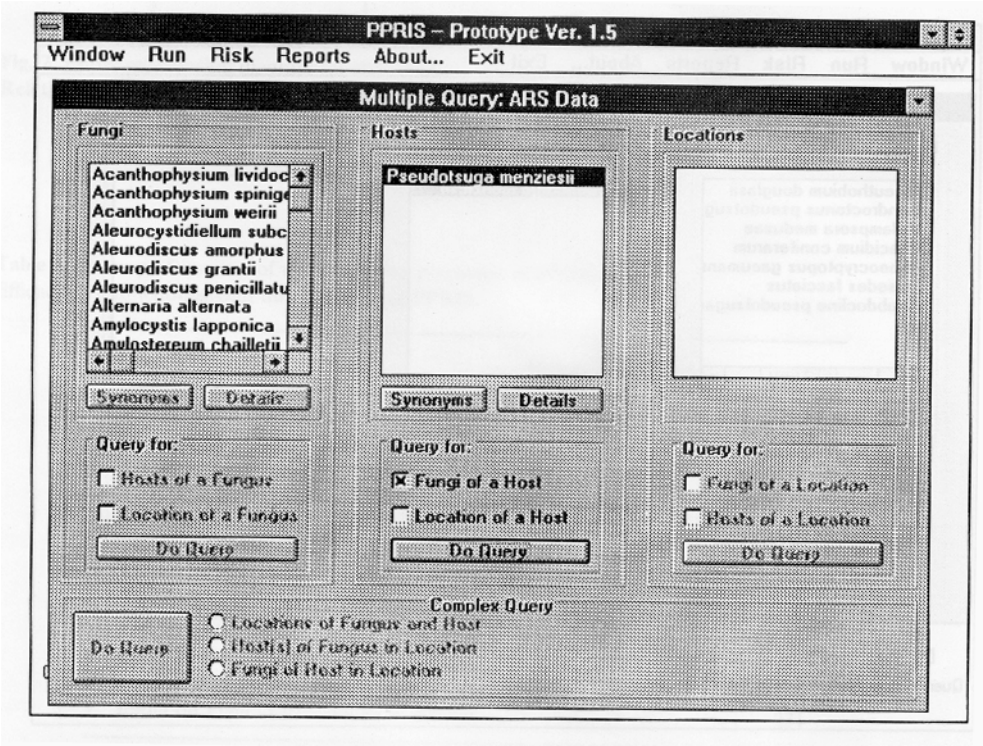


Fig. 4. Example of a query on fungi: fungi associated with *Pseudotsuga menziesii* in the USDA-ARS Fungi in Plants and Plant Products Database accessed through PPRIS.
Exemple d'une interrogation sur les champignons: champignons signalés sur *P. menziesii* selon la base de données de l'USDA-ARS, ave accés par PPRIS.

The prototype was designed for full functionality, data storage, query search, data entry and risk assessment reports. Manual data entry and direct printing of risk assessments were not included. Queries can be directly printed, but risk assessments must be copied to the Windows clipboard and then copied into Wordperfect for Windows ver. 5.2 as a text or graphic image.

Database queries

EPPO-PQ and USDA-ARS Fungi databases were first normalized and then imported into ORACLE tables. Query performance was tested on the ORACLE tables by selecting the query of interest and recording the time it took to complete the query. Queries included pest-host association, pest names, pests of a locality, hosts of a locality and geographic distributions of pests. Query performance was tested on a 486-66 MHz, 16 MB RAM microcomputer. The results of each query selection are displayed under the query history menu option and either printed to a file or sent directly to a printer. Each query result includes the number of records selected, database queried and length of time it took to process the query. Table 3 lists the number of records selected for each query and performance times for each query. Simple queries were completed in a matter of seconds; more complex queries required several minutes. Query performance times were related to the number of records retrieved by the prototype. Two representative query examples are included in this paper to demonstrate the functionality of the PPRIS prototype (Figs 3 and 4).

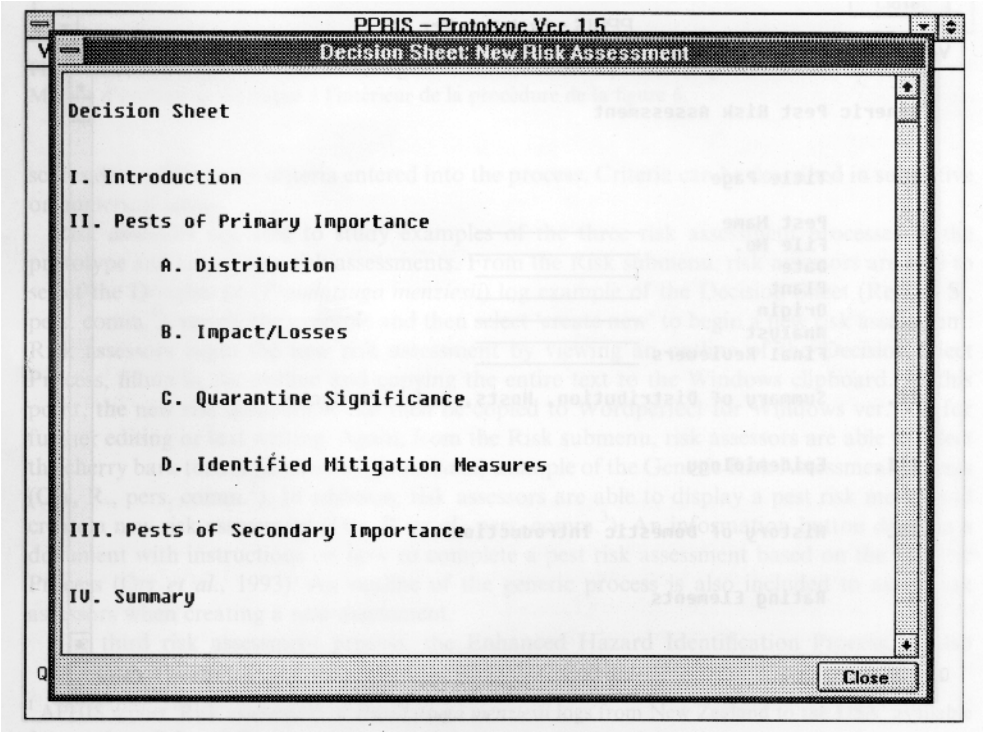


Fig 5. Decision sheet process for pest risk assessment.
Procédure ‘feuille de décision’ pour l’évaluation du risqué phyotsanitaire.

Risk assessment processes

Three risk assessment processes are illustrated in the evaluation prototype. The first process, the decision sheet (Fig. 5), relies on identifying the pests of primary and secondary importance. The process includes an introduction to the problem, pests of primary importance (with a description of their distribution), the impacts and losses attributed to the pests, their quarantine significance, identification of mitigation measures, pests of secondary importance, summary of overall risk, review of effective controls and treatments and pertinent references. The second process, generic risk assessment (Figs 6 and 7), is based on a pest risk assessment model. The model describes pest risk as equal to the probability of pest establishment and the consequence of the pest establishment. Pest establishment and consequences are further subdivided into smaller elements. Probability of pest establishment includes the elements of pest with host, entry potential, colonization potential and spread potential. Consequences of establishment include the elements of economic impact, environmental impact and impacts from social and/or political influences. Each of these elements is ranked high, medium or low risk, and an overall pest risk combining all of the elements is calculated and expressed as high, medium or low risk. Additional issues, data quality questions and references related to the pest risk assessment are also included in the generic process. The third process, Enhanced Hazard Identification (Fig. 8), is based on a criteria risk-ranking approach. Pests can be ranked and sorted by risk scores derived from the criteria entered into the process. Criteria can be described in subjective or numerical terms.

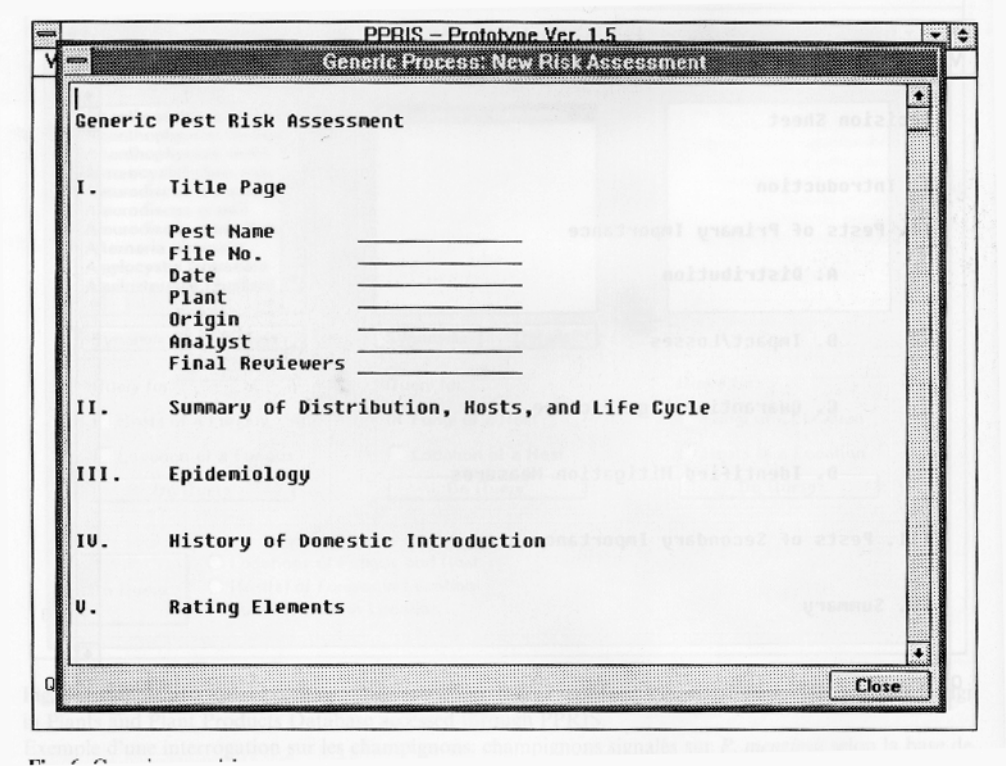
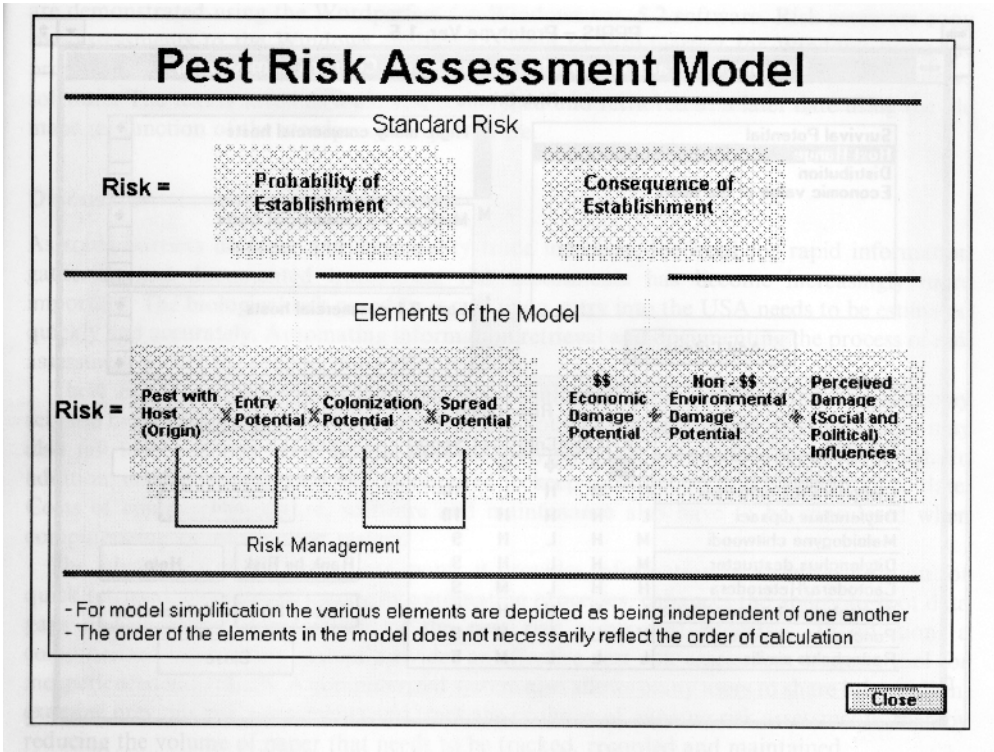


Fig. 6. Generic pest risk assessment process
Procéedure pour l'évaluation du risqué présenté par un organisme nuisible donné.



Fiug. 7. Pest risk assessment model of the generic risk assessment process (Fig. 6).
Modèle d'évaluation du risqué à l'intérieur de la procedure de la figure 6.

Risk assessors are able to study examples of the three risk assessment processes in the prototype and create new risk assessments. From the Risk submenu, risk assessors are able to select the Douglas fir (*Pseudotsuga menziesii*) log example of the Decision Sheet (Redlin, S. pers. comm.[5]), review the example and then select 'create new' to begin a new risk assessment. Risk assessors begin the new risk assessment by viewing an outline of the Decision Sheet Process, filling in the outline and copying the entire text to the Windows clipboard. At this point, the new risk assessment can then be copied to Wordperfect for Windows ver. 5.2, for further editing or text writing. Again, from the Risk submenu, risk assessors are able to select the cherry bark tortrix (*Enamornia formusana*) example of the Generic Risk Assessment process (Orr, R., pers. comm.[6]) In addition, risk assessors are able to display a pest risk model and create a new risk assessment (Orr, R. et al., perso. comm..[7]). An information button displays a document with instructions on how to complete a pest risk assessment based on the Generic Process (Orr et al., 1993). An outline of the generic process is also included to assist risk assessors when creating a new assessment.

[5] APHIS report 'Risk assessment of *Psuedotsua menziesii* logs from New Zealand to the USA' available from author, Cohen, S. D.
[6] APHIS report 'Pest risk assessment on cherry bark tortrix' available from author, Cohen, S.D.
[7] APHIS report 'Generic non-indigenous pest risk assessment process' available form author, Cohen, S. D.

The third risk assessment process, the Enhanced Hazard Identification Process, is also assessed from the Risk submenu. An example, 'Nematodes of Concern from Mexico,' is displayed to demonstrate this process, which relies on identifying, ranking and sorting criteria for each pest of concern (Griffin, R., pers. comm.[8]). A document describing the nematodes of concern example is displayed under the information button. After ranking each organism of concern by risk, additional criteria may be added, and organisms are ranked again. After viewing the example given, risk assessors are able to create a new enhanced hazard-identification risk assessment.

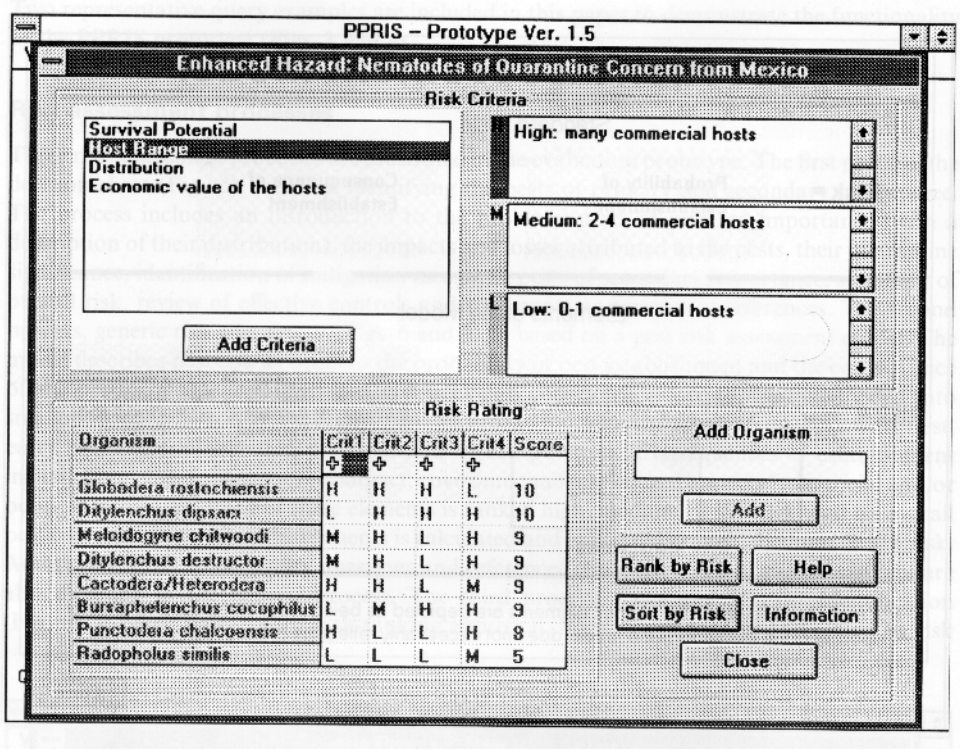


Fig. 8. Enhanced hazard identification risk assessment process, as illustrated in an example using nematodes from Mexico of quarantine concern for USA>
Procédure pour l'identification accélérée de la priorité à accorder dans une série d'organismes présentant des dangers différents, illustrée par des nematodes presents au Mexique et présentant une risqué pour les Etats-Unis.

[8] APHIS report 'Nematodes of concern from Mexico' available from author, Cohen, S. D.

Risk assessment retrieval and storage

PPRIS is designed to retrieve and store documents from document-imaging equipment and compact discs located on a local area network. Access to document-imaging equipment and compact discs on a local area network has not been included in this evaluation prototype but will be included in the implementation phase of the project. Currently, the evaluation prototype does have the ability to access Silver=Platter compact discs such as the CABPEST compact disk, on a single microcomputer. Risk assessment document search, retrieval and storage functions are demonstrated using the Wordperfect for Winders ver 5.2 software. Risk assessors copy risk assessments to the Windows clipboard, switch to Wordperfect for Windows using the program manager function and past the risk assessment text into Wordperfect for Windows software. The text is save as a file and is searched and retrieved at a later date using the file manager function of the word-processing software.

Discussion

As trade barriers decrease and commodity trade increases, the need for rapid information gathering and documented transparent risk assessments have become increasingly more important. The biological risk posed by a pest upon entry into the USA needs to be estimated quickly and accurately. Automating information retrieval and documenting the process of risk assessment makes the process more effective.

There are some drawbacks to computerizing an information system. Pest risk assessors may rely too heavily on the information presented and not seek outside experts. Risk assessors may also fall into a routine and do less analysis, relying upon automation over judgment. In addition, careful maintenance will be required to keep information in the system up to date. Costs of computer hardware, software and maintenance also have to be considered when computerizing an information system.

The advantages of the system are many: it provides information in a central location for quick retrieval, increases efficiency by automating processes, enhances the ability to spot data gaps and improves organization of the pest risk assessment processes. In addition, a computerized information system provides an effective pest risk assessment training tool for inexperienced individuals. A computerized system also allows many users to share information, examine previous risk assessments and track the progress of ongoing risk assessments, thereby reducing the volume of paper that needs to be tracked, recorded and maintained.

The disadvantages of the system may be overcome in part by good documentation of the processes necessary for completing pest risk assessments. These processes would include consulting with outside experts, incorporating the date of the data for determining the timeliness of the information, maintaining up to date bibliographic databases and adding analytical questions that must be answered for specific pest issues.

Designing and prototyping a system is a good communication tool for users. Prototyping quickly captures concepts and allows users and managers to visualize system functionality. Mistakes in system design are more easily rectified at the prototype state of the process than after final programming for the system.

The effectiveness of this system is dependent on the timeliness and accuracy of the data. Data must be tagged with the source and date. Also, use of different data formats, imaged documents, on-line databases and CD-ROM bibliographic sources give the system flexibility and accuracy by cross-checking different sources.

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Systéme d/information sur les risques phytosanitaires PPRIS de l/USDA/APHIS: conception d/un prototype opérationnel

Un systéme d'information sur les risques phytosanitaires (PPRIS, pour Plant Pest Risk Information System) est en cours de développement aux Etats-Unis. Ce systéme informatisé d'aide à la decision en evaluation du risqué phytosanitaire est destine au personnel du service de la protection des végétaux (APHIS) du Ministère de l'Agriculture (USDA). La construction de PPRIS lui permettra d'acquérir des données à partir de diverses sources extérieures: base de données PQ de l'OEPP, base de données du Service de recherché (ARS) de l'USDA sur les champignons signalés sur les végétaux et produits végétaux, bases de données bibliographiques sur CD-Rom, bases de données accessibles par INTERNET, documents sur l'évaluation des risques. PPRIS donnera également accés àdiverses procedures pou l'évaluation des risques. Un prototype de PPRIS pour evaluation a été créé en Visual Basic ver. 3.0 dans l'environnement Windows 3.1 Les banques de données PQ de l'OEPP et sur les champignons de l'ARS ont été importees et stockées en ORACLE ver. 6.0 L'effcacité de l'interrogation de ces deux bases en ORACLE a été vérifée. Le prototype permit aussi d'accéder au CD-ROM bibliographique CABPEST et à un logiciel de communication assurant la liaison avec des bases de données lointaines. Trois procedures pour l'évaluation des risques présenté par un organisme nuisible donné, l'identification accélérée le la priorité à Wordperfect for Windows, par le Windows Program Manager, afin de sauvegrader ou de récupérer des documents concernant l'évaluation des risqus.

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